

WHAT IS CLAIMED IS:

1. An electron beam system comprising:  
an electron gun for emitting an electron beam and  
for irradiating said electron beam against a sample;  
an electron lens for magnifying the electron beam  
having passed through the sample; and  
a detector for detecting said magnified electron  
beam so as to form an image of the sample.
2. An electron beam system in accordance with claim 1,  
in which said sample is a stencil mask or a mask having a  
pattern formed on a membrane.
3. An electron beam system in accordance with claim 1  
or 2, further comprising an NA aperture disposed between  
the electron gun and said sample, wherein said electron  
beam is passed through the NA aperture, thereby allowing  
the well-collimated electron beam to be irradiated to said  
sample.
4. An electron beam system in accordance with any one  
of claims 1 through 3, further comprising at least one  
shaping aperture disposed between the electron gun and  
said sample, wherein  
said electron beam is passed through said shaping  
aperture and irradiated to said sample surface, thereby  
allowing an image of said shaping aperture to be formed on  
the surface of said sample.
5. An electron beam system in accordance with any one  
of claims 1 through 3, further comprising a plurality of  
shaping apertures disposed in the vicinity of an optical

axis of said electron beam system, wherein

an area on said sample to be irradiated is made variable by changing overlaps of said plurality of shaping apertures with each other.

6. An electron beam system in accordance with any one of claims 1 through 5, in which

said electron gun has a thermionic emission cathode and is operable under the space-charge-limited condition.

7. An electron beam system in accordance with claim 1, further comprising at least two-stage of electron lenses disposed between said sample and said detector, wherein

said electron beam passes through said sample and further through said two-stage of electron lenses to be irradiated onto said detector.

8. An electron beam system in accordance with claim 1, further comprising an entrance pupil of an irradiation lens system disposed between said electron gun and said sample, wherein

a source image is formed in said entrance pupil.

9. An electron beam system in accordance with claim 8, further comprising a magnifying lens disposed between said sample and said detector, wherein

a magnification of said magnifying lens is made variable in response to a size of an irradiation area of said electron beam as measured on the sample.

10. An electron beam system in accordance with claim 5, in which

the irradiation area of said electron beam on said

sample is defined to be a rectangular shape having long sides and short sides by changing the overlaps of said plurality of shaping apertures with each other; and

said system further comprises a sample table on which said sample is loaded; wherein

a detection of said sample is carried out by said detector while moving said sample table carrying the sample continuously in the direction of said short sides.

11. An electron beam system in accordance with claim 1, further comprising a scanning means for controlling said electron beam to make a scanning motion in a step-by-step manner or continuously.

12. An electron beam system in accordance with claim 1, in which

said detector comprises:

a scintillator that changes the electron beam to an image of light;

an optical lens for adjusting a size of the image of light produced by said scintillator or an optical system for projecting said image of light at a ratio of 1 to 1; and

either one of a CCD detector or a TDI detector on which the image of light whose size has been adjusted by said optical lens is to be formed.

13. An electron beam system in accordance with claim 1, in which

said electron gun is such a electron gun of small light source image having a FE, a TFE or a Schottky

cathode.

14. An electron beam system in accordance with claim 1, in which

said electron gun is disposed under said sample, and said detector for detecting a defect in said sample is disposed above said sample.

15. An electron beam system in accordance with claim 1, in which

a plurality of magnifying lenses for magnifying the electron beam is disposed between said electron gun and said detector, wherein

a magnifying lens serving as the first one to magnify the electron beam that has passed through said sample is a doublet lens.

16. An electron beam system in accordance with claim 15, in which

an NA aperture is disposed between said plurality of magnifying lenses, wherein

said NA aperture is able to remove those electron beams of bad collimation that have been scattered by said sample.

17. An electron beam system in accordance with claim 12, in which

said scintillator is disposed in vacuum;

said optical lens and said CCD or TDI detector are disposed in atmosphere; and

a vacuum window is arranged between said scintillator and said optical lens for taking out said

image of light so as to be directed to said optical lens disposed in atmosphere.

18. An electron beam system in accordance with claim 12, in which

said scintillator, said optical lens and said CCD or TDI detector are disposed in vacuum.

19. An electron beam system in accordance with claim 1, in which

said detector comprises an image detector, wherein said image detector is composed of an MCP and an EB-CCD detector or an EB-CCD, or otherwise a MCP and an EB-TDI detector or an EB-TDI.

20. An electron beam system in accordance with claim 1, in which

a second detector for detecting secondary electrons or back scattering electrons, which are generated upon scanning of said sample with said electron beam, is disposed between said sample and said electron gun.

21. An electron beam system in accordance with claim 20, in which

by changing a focal length of the lens, a crossover image is formed so as to scan a sample surface of said sample with said crossover image, or by reducing an overlap between two shaping apertures, an electron beam of small diameter is produced so as to scan the sample surface of said sample with said electron beam of small diameter, thereby carrying out a registration of said sample.

22. An electron beam system in accordance with claim 1, in which

an equivalent frequency of said system is set to be equal to or higher than 200 MHz.

23. An electron beam system in accordance with any one of claims 1 through 22, further comprising:

a storage unit in which reference pattern data is stored in advance; and

a control unit for comparing image data obtained from the electron beam having passed through said sample to said pattern data, wherein

said control unit carries out the defect inspection of said sample based on the comparison of said image data to said pattern data.

24. An electron beam system, in which an electron beam emitted from an electron gun is irradiated to a stencil mask, and electrons having passed through said stencil mask are detected to thereby detect a defect in said stencil mask.

25. An electron beam system in accordance with claim 24, in which

said electron beam irradiation section comprises a plurality of optical systems.

26. A manufacturing method of a semiconductor device comprising a step of using a stencil mask which has been inspected for any defect by using the electron beam system defined by any one of claims 22 through 25.

27. A semiconductor manufacturing apparatus for a wafer

or a mask, said apparatus including a defect inspection apparatus incorporated therein.

28. A semiconductor manufacturing apparatus in accordance with claim 27, in which

said defect inspection apparatus is such a defect inspection apparatus that uses an energy beam, wherein said defect inspection apparatus is integrated with said semiconductor manufacturing apparatus to construct a single unit.

29. A semiconductor manufacturing apparatus in accordance with claim 27 or 28, in which

said semiconductor manufacturing apparatus comprises an etching (pattern forming) section, a cleaning section, a drying section, an inspecting section equipped with said defect inspection apparatus, and a load section and an unload section, wherein said inspecting section is arranged close to either one or two or three of said etching section, said drying section and said unload section.

30. A semiconductor manufacturing apparatus in accordance with any one of claims 27 through 29, in which

said defect inspection apparatus is an electron beam defect inspection apparatus, wherein said semiconductor manufacturing apparatus includes a cleaning unit and a drying unit each incorporated therein.

31. A semiconductor manufacturing apparatus in accordance with claim 30, in which

said electron beam defect inspection apparatus is

equipped with a differential exhaust system.

32. A semiconductor manufacturing apparatus in accordance with claim 31, in which

an electron beam irradiation area on a sample surface is evacuated by said differential exhausting system.

33. A semiconductor manufacturing apparatus in accordance with any one of claims 30 through 32, in which

said defect inspection apparatus is an electron beam defect inspection apparatus of scanning-type electron microscope (SEM) system.

34. A semiconductor manufacturing apparatus in accordance with claim 33, in which

a primary electron beam used in said electron beam defect inspection apparatus is composed of a plurality of electron beams, and secondary electrons from the sample is deflected from an optical axis of the primary electron beam by an E x B separator (Wien filter) so as to be detected by a plurality of electron beam detectors.

35. A semiconductor manufacturing apparatus in accordance with any one of claims 30 through 32, in which

said defect inspection apparatus is an electron beam defect inspection apparatus of image projection-type electron microscope system.

36. A semiconductor manufacturing apparatus in accordance with claim 35, in which

a primary electron beam used in said electron beam defect inspection apparatus is composed of a plurality of



electron beams, wherein said plurality of electron beams is irradiated to a sample while scanning it, and secondary electrons from the sample is deflected from an optical axis of the primary electron beam by an  $E \times B$  separator (Wien filter) so as to be detected by a two-dimensional or line image sensor.

37. An electron beam system representing a defect inspection apparatus, in which an electron beam emitted from a  $LaB_6$  electron gun is shaped properly and irradiated to a sample, and an electron beam emanated from said sample is formed into an image by an optical system of image projection-type electron microscope system, wherein said electron beam system comprises a load lock chamber for loading and unloading, and said  $LaB_6$  electron gun is operable under a space-charge-limited condition.

38. An electron beam system in accordance with claim 37, in which

said electron beam emanated from said sample consists of back-scattered electrons or transmission electrons.

39. An electron beam system in accordance with claim 37, which has employed such a system, in which

a image projected sample image is converted into an optical image by a scintillator screen, and said optical image is formed on a TDI detector by an FOP or a lens system.

40. An electron beam system in accordance with claim 37, which has employed such a system, in which

a image projected sample image is formed on a TDI detector having a sensitivity to the electron beam.

41. An electron beam system in accordance with claim 37, in which

said sample is fixedly mounted on a sample table by an electrostatic chuck, a laser interferometer is arranged for measuring a position of said sample table, and said sample is fixedly held by the electrostatic chuck even in said load lock chamber.

42. A semiconductor device manufacturing method, in which a wafer in the course of processing is inspected by using the defect inspection apparatus defined by any one of claims 27 through 41.

43. A device manufacturing method, in which a defect inspection and a defect analysis are applied to a wafer or a mask after one of processing processes is finished, and a result therefrom is fed back to the processing process.

44. An electron beam system, in which a primary electron beam emitted from an electron gun is irradiated to a sample surface of a sample prepared as a subject to be inspected, and an electron image formed by a secondary electron beam emanated from said sample is magnified and detected, said system comprising,

an NA aperture disposed on an optical path common to said primary electron beam and said secondary electron beam, and

an electron lens disposed in the vicinity of said sample surface, wherein

a crossover produced by said electron gun, said electron lens and said NA aperture are in the conjugate relationships to each other.

45. An electron beam system in accordance with claim 44, in which said NA aperture image is formed on or in the vicinity of a principal plane of said electron lens.

46. An electron beam system in accordance with claim 45, in which

a shaping aperture is arranged on said path of said primary electron beam, and

said shaping aperture and said sample are defined as conjugate planes.

47. An electron beam system, in which a primary electron beam is irradiated to a sample surface, and secondary electrons emanated from the sample is magnified as an image to be detected, in which

a configuration of beam to be irradiated to the sample surface is designed to have a distribution of its intensity that is lower in the vicinity of an optical axis and higher in a location away from the optical axis.

48. An electron beam system in accordance with any one of claims 44 through 46, in which

a configuration of beam to be irradiated to the sample surface is designed to have a distribution of its intensity that is lower in the vicinity of an optical axis and higher in a location away from the optical axis.

49. An electron beam system, in which a primary electron beam is directed into a sample surface vertically by using

an E x B separator, and secondary electrons or back scattering electrons emanated from said sample surface are magnified as an image by using at least two-stage of lenses to be detected, wherein said E x B separator is disposed between an electron lens located downstream most in a path of said electron beam and a detector.

50. An electron beam system in accordance with any one of claims 44 through 48, in which at least two-stage of lenses are disposed on a path of secondary electrons or back scattering electrons, wherein said E x B separator is disposed between one of said two-stage of electron lenses that is located downstream in said path of said electron beam and a detector.

51. An electron beam system, in which a primary electron beam is directed into a sample surface vertically by using an E x B separator, and secondary electrons or back scattering electrons which are emanated from said sample are magnified as an image to be detected, wherein

said E x B separator is configured such that a deflection angle of the secondary electrons caused by a magnetic field is about two times as large as that by the electric field.

52. An electron beam system in accordance with claim 49 or claim 50, in which

said E x B separator is configured such that a deflection angle of the secondary electrons caused by a magnetic field is about two times as large as that by the electric field.

53. An electron beam system in accordance with claim 51 or 52, in which

said E x B separator is set to deflect the secondary electrons or the back scattering electrons having a level of about 4500eV, and also set to deflect the secondary electron beam by an angle of 7° to 15° relative to an optical axis of the secondary electron beam.

54. An electron beam system, in which a primary electron beam emitted from an electron gun is irradiated to a sample prepared as a subject to be inspected, and an electron image formed by its transmission electron beam having passed through the sample is magnified and detected, wherein

an NA aperture is disposed on a path of said transmission electron beam and an electron lens is disposed in the vicinity of said sample, and

a crossover produced by said electron gun, said electron lens and said NA aperture are in the conjugate relationships to each other.

55. An electron beam system in accordance with claim 54, in which a crossover image of the electron gun by said transmission electron beam is formed on or in the vicinity of a principal plane of said electron lens.

56. An electron beam system in accordance with claim 55, in which

a shaping aperture is disposed on a path of said primary electron beam, wherein

said shaping aperture and said sample are arranged

to be in the conjugate relationship to each other.

57. An electron beam system, in which an electron image of secondary electrons emanated from a sample surface, back scattering electrons or an electron having passed through the sample is magnified by at least two-stage of electron lenses and then detected, wherein a magnified image produced by a first stage of electron lens is focused on a certain point upstream to a second stage of electron lens to thereby reduce a distortion aberration or a magnification aberration.

58. An electron beam system in accordance with any one of claims 54 through 56, in which

at least two-stage of electron lenses are disposed on the path of said transmission electron beam, wherein a magnified image produced by a first stage of electron lens is focused on a certain point upstream to a second stage of electron lens.

59. An electron beam system, in which a primary electron beam is irradiated to a sample, and an image of secondary electrons emanated from the sample, an image of back scattering electrons or an image of transmission electrons having passed through the sample is magnified and detected as an image, wherein

a distortion aberration in the detected image is simulated by calculation to thereby determine a difference between a third order of absolute value and a fifth order of absolute value of the distortion aberration, and a compensation parameter is optimized such that said

difference is minimized or that the fifth order of absolute value is greater than the third order of absolute value by about 5 to 15%, wherein a position of a magnified image produced by a first stage of electron lens is set in response to said optimized compensation parameter.

60. An electron beam system in accordance with claim 57 or 58, in which

the distortion aberration in the detected image is simulated by calculation to thereby determine a difference between a third order of absolute value and a fifth order of absolute value of the distortion aberration, and a compensation parameter is optimized such that said difference is minimized or that the fifth order of absolute value is greater than the third order of absolute value by about 5 to 15%, wherein

said compensation parameter is a distance between said second stage of electron lens and the magnified image, and the position of the magnified image produced by the first stage of electron lens is set in response to said optimized compensation parameter.

61. An electron beam system, in which electrons having passed through a sample is magnified as a transmission electron image by an electron lens disposed close to said sample so as to be detected by either one of a CCD, a TDI or an EBCCD, wherein

when a magnification for magnifying said transmission electron image is to be changed, a distance between said sample and said objective lens is changed.

62. An electron beam system in accordance with any one of claims 54 through 60, further comprising an adjusting means for adjusting a distance between said sample and said electron lens disposed close to the sample when one sample is changed to another.

63. An electron beam system in accordance with any one of claims 44 through 62, in which said electron lens disposed close to the sample surface comprises an electromagnetic lens including a gap created in the sample side.

64. A manufacturing method of a semiconductor device, in which a semiconductor wafer representing said sample to be inspected is inspected for any defect by using the electron beam system defined by any one of claims 44 through 53, claim 57, claim 59, claim 60 and claim 63.

65. A manufacturing method of a semiconductor device, in which a mask is used, which has been inspected for any defect by using the electron beam system defined by any one of claims 54 through 63.